Arteriovenous malformations: Current status of surgery

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The treatment of arteriovenous malformations (AVMs) has undergone a wide swing in the last two decades with the emergence of minimally invasive procedures of endovascular neuroradiological treatment and the non-invasive method of treatment by radiosurgery. Despite this, the century-old and well-established surgical method of treatment constitutes the principal form of treatment. Whilst a small proportion of cases can be primarily treated by embolization alone, this mode of therapy has been seen as an adjunct to surgery. The long-term outcome of radiosurgery and its effects and effectiveness will have to be assessed.

Surgery on AVMs requires precise dissection techniques, surgical skills and experience. However, the increasing trend of subjecting the patients to non-surgical ‘safer’ methods of treatment by radiosurgery has depleted the total number of AVM cases currently treated by surgery.

Unlike the treatment of aneurysms, the treatment of AVM by the endovascular route has not yet been convincingly proven. There are only a small minority of cases of AVMs that can be completely treated by embolization alone. The majority will be incompletely treated and will need surgical resection. Partial or incomplete treatment has been shown by a number of authors to have no benefit as regards symptomatic improvement or in the long-term clinical outcome. The opinion as regards the case selection for preoperative embolization varies. A number of surgeons do not find preoperative embolization necessary for all surgically treated cases. Complications of endovascular embolization in the form of intracerebral paraneidal bleeding can be a difficult surgical problem.

Only selected cases have been reported to be suitable for the radiosurgical method of treatment. The effects of the treatment are not uniform and many of the treated cases may need surgery.

Essentially, it implies that surgery has a vital role in the treatment of AVMs. Surgical resection of the AVMs is the only time-proven method of cure from the pathology of AVM. Apart from the technical skills necessary to surgically treat AVMS, experience in treating these cases is crucially important. A number of cases considered suitable for radiosurgery or for embolization as a primary form of treatment are relatively ‘simple’ surgical cases and can form a vital surgical bank of experience for young and emerging surgeons.

Whilst considering the patient a suitable candidate for surgery a variety of issues must be considered.

The size of the nidus and feeding and draining vessels: The size of the nidus, its feeding and draining vessels are amongst the most important factors that determine the course of the surgery. AVMs with large and fewer feeding vessels are better for surgery than those with small and multiple feeding vessels. The location of the feeding vessels in relationship to the nidus and to the direction of the surgical approach are crucial factors that need to be considered whilst planning for surgery and for assessing the need for preoperative embolization.

The location of the nidus: AVMs located in the posterior cranial fossa are in general easier and safer to operate than supratentorial AVMs. The posterior parieto-occipital AVMs are relatively more common. Such AVMs are usually most suitable for surgery. AVMs located in the frontal brain and in the anterior temporal lobe are also good candidates for surgery. Whilst selecting a case for surgery for lesions located in the eloquent areas, other factors related to the AVM must be considered prior to making the decision for surgery.

Degree of flow in the AVM: Degree of flow in the AVM is probably a most important factor that can affect the execution of the surgery. The degree of flow in the AVM can be assessed during the angiography procedure. The rate of flow of the dye into and outside the AVM can be evaluated. The presence of flow-related aneurysm over the feeding vessel of the AVM is suggestive of a high rate of blood flow within the AVM. The number of territories feeding the AVM is also indicative of the degree of flow. The territories are divided into anterior cerebral artery territory, middle cerebral artery territory and posterior circulation territory. The more the number of territories feeding the AVM, the higher is the degree of flow within the AVM. The size of the draining vein can also point towards the rate of flow within the AVM. Larger the draining veins, higher the rate of blood flow in the AVM.

Nature of the nidus: The nidus can be varied in nature.
AVMs with a diffuse nidus are significantly more difficult to operate than AVMs with a localized nidus. Nidus can on occasion be multiple. Such AVMs can be difficult to operate. Nidus can be subcortical, paraventricular or deep cortical. The site, nature and multiplicity of the nidus need to be assessed.

Symptoms at the time of presentation: AVM is a congenital malformation of blood vessels and is present since birth. The presentation can be in a variety of patterns. It can be with headache, convulsions, focal neurological deficit and with symptoms suggestive of a bleed. When deciding on surgery one must take into account the nature of AVM, possible complications related to surgery and the nature of symptoms. The re-bleeding rate of AVMs, which is significantly lower than that of aneurysms, should also be considered.

Need for treatment: Whilst surgery for AVM has its own place, it can be one of the most difficult and dangerous neuro-surgical endeavors. A variety of factors need to be considered prior to selecting a case for surgery. A very important and probably a vital issue that needs to be addressed is whether the AVM needs to be treated at all. Whenever the symptoms are relatively subtle and when they can be treated with drugs, surgery or any other form of treatment should be withheld or delayed.

Whether the AVM is treatable: Some AVMs, particularly those which are diffuse in nature, deep-seated, high-flow or those located in eloquent areas can be unsafe, difficult or impossible to treat by surgery or by any other method. Such AVMs, which constitute a significant proportion of AVMs, should be treated only for symptoms with drugs. Radiosurgery is generally not advocated or suitable for such patients and partial treatment by embolization is not advisable and can be dangerous. Such AVMs should be treated with ‘no surgical treatment’ strategy. Depending on the experience of the treating surgeon, the inclusions in this category may vary to a small extent.

We divided AVMs into the following groups depending on the case of the surgical procedure. The degree of surgery-related difficulties will depend to a great extent on the experience of the surgeon. There are no definite or strict criteria for the sub-classification, but it depends on the gross visual impression of the surgeon.

1. Easy AVMs
2. Difficult but safe
3. Very difficult but risky but possible
4. Not safe or possible due to the type or site of AVM

Easy AVMs: Small-sized AVMs with a single territory feeder, having a slow flow and in a non-eloquent region of the brain are ‘easy’ for surgery. The venous drainage of these AVMs is also usually in the form of a single large vein draining into a single sinus. Such AVMs should always be treated by surgery. AVMs located in an eloquent area, having a single territory feeder and single territory venous drainage, can also be safely treated by surgery. Such AVMs constitute a good and safe surgical bank for acquiring experience and confidence in the treatment of AVMs. In our opinion, subjecting these patients to any other form of treatment will be an incorrect decision.

Difficult but safe AVMs: AVMs having more than one territory feeders, associated aneurysms and those located in less eloquent or deeper areas of the brain belong to this category. If the symptoms are significant, surgery is in general, the best treatment option in such cases. Preoperative embolization of the AVM is not necessary.

Very difficult and risky but possible: AVMs with multiple feeders and with a high flow can sometimes be a very difficult surgical challenge. In such cases the decision whether to treat or not is crucial. No surgery or any other intervention should be done unless the symptoms are absolutely compelling. Indication of preoperative embolization will depend on the site of the feeding vessels.

Not safe or possible due to the type and site of AVM: A significant group of AVMs cannot or should not be treated. Diffuse or multiple nidus, extensive and high-flow AVMs and those located in eloquent areas or deep in the brain form such a group. Surgery can be fraught with dangers of severe neurological deficits and should be avoided. The patient may be treated for symptoms with drugs.

Surgery for arteriovenous malformations

While some AVMs can be simple and straightforward surgical operations, some need extensive planning and tedious, painstaking and meticulous execution. A high degree of surgical confidence is mandatory as some of these lesions can be formidable problems.

Planning: The planning of surgery should take into account the location and the degree of flow of the AVM. The exact number and site of the feeding vessels and the draining veins must be deciphered in a three-dimensional perspective. The surgical strategy regarding the direction of exposure of the AVM to deal with the arterial feeders must be appropriately planned. The AVM nidus should be identified early in the operation and a circumferential dissection around the nidus should be carried out. Usually it is better to isolate feeding vessels close to the nidus and then coagulate and cut them. Excessive coagulation of the region can be counter-effective. Sometimes during the course of dissection, there can be bleeding from more than one point. In high-flow AVMs, the bleeding may sometimes appear as if it is getting out of control, and patience and persistence are necessary to control the bleeding. Most of the large AVMs will have a feeding vessel from an intraventricular choroidal blood vessel. Control of this feeder is sometimes crucial in controlling the bleeding. Small capillary-like blood vessels are sometime difficult to coagulate. These small vessels usually have a feeding ‘mother’ vessel, which needs to be isolated and coagulated. Spending too much time in controlling small ‘capillary-like’ vessels is usually not
necessary. A large draining vein must always be preserved till the entire dissection of the AVM is completed. The bleeding can continue till the entire nidus is dissected and removed.

Opinion varies as regards the treatment of aneurysms located over the feeding vessel of the AVM. Our experience suggests that the surgical resection of the AVM is usually sufficient or necessary and the feeding vessel aneurysm will thrombose over the period. However, if the aneurysm is within the surgical field, it is worthwhile to treat it surgically. In cases where the aneurysm has bled, it may be a reasonable idea to embolize the aneurysm.

**Postoperative management:** If the entire AVM nidus is resected and adequate hemostasis is confirmed prior to closure, postoperative hemorrhage is rare. The usual cause of postoperative hemorrhage and other related problems is incomplete resection of the AVM. After a successful resection there is a tremendous realignment of intracranial circulation. Postoperative neurological deficits even if they are significant are usually temporary and will improve with time. Successful resection of the nidus usually means cure from the disease.